

## Accumulator and Debuncher Revolution Frequencies

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The purpose of this Note is to identify what parameters determine the proper setting of the Accumulator and Debuncher dipole buses, and what the  $\bar{p}$  revolution frequencies should be under these circumstances. As will be seen, certain parameters of the Main Ring lead to very tight tolerances in these bus settings.

There has been some effort over the last several days to "optimize" the bus settings. This has included adjusting the Debuncher dipole bus to optimize flux from AP-2, and adjusting the Accumulator dipole bus to optimize flux from the Debuncher. This is not the correct procedure.

### Parameters which determine settings

There are 4 parameters which completely determine the proper dipole bus settings for the Debuncher and Accumulator. They are:

1. Main Ring RF frequency for 120GeV protons. In order to perform bunch rotation in the Debuncher, the Debuncher revolution frequency must be the 90<sup>th</sup> subharmonic of the Main Ring RF frequency for 120 GeV (kinetic) protons. It is believed that the Main Ring radius at 120 GeV is 1000.0084 meters, leading to a Debuncher revolution frequency of 590,033.6 Hz.

2. The Main Ring energy at 8 GeV. The injection energy of the Main Ring at 8 GeV is not exactly 8 GeV but is determined by the Booster phase lock frequency (52.81280 MHz) and the Main Ring radius for injection (1000.0093 meters). These lead to an injection energy of (kinetic) 8.02474 GeV.

3. The Δp/p between the Accumulator injection and extraction orbits. The Accumulator injection orbit was designed to be 0.1% higher momentum than the extraction orbit. This means that the energy of the Debuncher is 8.03361 GeV.

4. The Main Ring RF frequency at 8 GeV. As we anticipate doing a bunch to bucket transfer of  $\bar{p}$ 's from the Accumulator extraction orbit to the Main Ring, it is required that there be an Accumulator  $\leftrightarrow$  Main Ring phase lock at 52.81280 MHz for injection. Hence the revolution frequency at extraction is 628723.8 Hz.

These four parameters, since they define both the energy of the  $\bar{p}$ 's and their revolution frequency in both rings, also determine the circumference of these rings. As there is some limit to the adjustment of the orbit circumference from the design, it may be necessary to adjust one or more of the 4 input parameters as necessary to achieve acceptable orbits in both rings.

Results for 120 GeV (kinetic) primary protons (see Appendix)

<u>Parameter</u>	<u>Debuncher</u>	<u>Accumulator</u>
Kinetic energy	8.03361	8.02474 GeV
Total energy	8.97189	8.96302 GeV
Momentum	8.92269	8.91378 GeV/c
Revolution Frequency	590,033.6 <sup>(a)</sup>	628,723.8 <sup>(d)</sup> Hz
Circumference	505.3077 <sup>(c)</sup>	474.2071 m
Design circumference	505.2822 <sup>(a)</sup>	474.2070 <sup>(b)</sup> m
Δ circumference	.0255 <sup>(e)</sup>	.0001 m

(a) Dave Johnson 7/17/85. Also Synch run / Design Report (9/84) Appendix D.

b) Dave Johnson 7/17/85. This was 474.2020 m (D. Johnson 2/85), and 474.2024 m (Design Report (9/84) Appendix D).

c) If the  $\bar{p}$  production energy is raised from 120 GeV to 140 GeV (kinetic) the revolution frequency of the Debuncher is raised 4.7 Hz to 590,038.3 Hz, and the circumference is reduced by 0.004 m to 505.3037 m.

d) Using  $\gamma = 0.023$ , the injection revolution frequency is

$$f_{\text{inj}} = f_{\text{ext}} \left(1 - \frac{\gamma \Delta p}{p}\right) = 628709.3 \text{ Hz}$$

e) Corresponds to  $\frac{\Delta p}{p} = \gamma^2 \frac{\Delta C}{C} = \frac{(7.65)^2 \cdot 0.0255}{505.28} = 0.3\%$  (less than 1% of aperture)

Appendix

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1 ! PROGRAM "KINEMATICS"
2 ! R. SHAFER 9/8/85
3 PRINTER IS 701
4 M=.9382796
5 C=2.99792458E+8 ] Wallet card values
6 R=1000.0093
7 Mrrf=5.28128E+7
8 B=Mrrf*2*PI*R/(1113*C)
9 G=1/SQR(1-B*B)
10 E=G*M
11 T=E-M
12 P=B*E
13 Af=Mrrf/84
14 Ac=2*PI*R*Mrrf/(1113*Af)
15 PRINT "ENERGY= ",E
16 PRINT "K.E.= ",T
17 PRINT "MOMENTUM= ",P
18 PRINT "FREQUENCY= ",Af
19 PRINT "CIRCUMFERENCE=",Ac
20 PRINT ""
21 Mrt=120 ← 120 GeV primaries
22 G=(Mrt+M)/M
23 B=1/SQR(1+1/G^2)
24 R=1000.0084
25 Mrrf=1113*B*C/(2*PI*R)
26 Dpop=.001 ← CP/p
27 Df=Mrrf/90
28 P=P*(1+Dpop)
29 B=1/SQR(1+(M/P)^2)
30 E=P/B
31 T=E-M
32 Dc=B*C/DF
33 PRINT "ENERGY= ",E
34 PRINT "K.E.= ",T
35 PRINT "MOMENTUM= ",P
36 PRINT "FREQUENCY= ",Df
37 PRINT "CIRCUMFERENCE=",Dc
38 PRINTER IS CRT
39 END

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ENERGY=	8.9630235732
K.E.=	8.0247439732
MOMENTUM=	8.91377714361
FREQUENCY=	628723.809524
CIRCUMFERENCE=	474.207074778

ENERGY=	8.97188842302
K.E.=	8.03360882302
MOMENTUM=	8.92269092076
FREQUENCY=	590033.637616
CIRCUMFERENCE=	505.307701065

Program is on HP computer  
in AP-10

Accumulator Extraction Orbit

Debuncher "Central" Orbit